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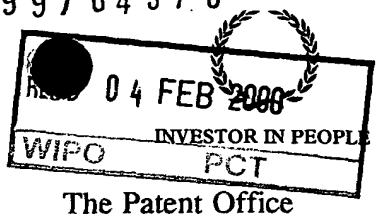

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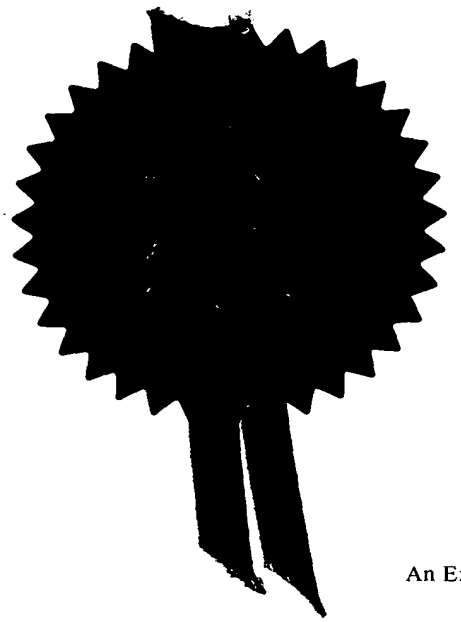

Signed Andrew Gerry

Dated 26 January 2000

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2. Patent application number *(The Patent Office will fill in this part)* — **9901234.6** — 20 JAN 1999

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Microscience Limited
67-68 Jermyn Street
London
SW1Y 6NY
United Kingdom

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom 7304S46001

4. Title of the invention — PROTEIN AND COMPOSITIONS CONTAINING IT

5. Name of your agent *(if you have one)* — GILL JENNINGS & EVERY

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

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EC2M 7LH

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Claim(s)	1
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11. For the Applicant
Gill Jennings & Every

I/We request the grant of a patent on the basis of this application.

Signature

Date
20 January 1999

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PERRY, Robert Edward
0171 377 1377

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PROTEIN AND COMPOSITIONS CONTAINING IT

Field of the Invention

This invention relates to one protein, to vaccines containing it, and to its use in therapy, for immunisation.

Background to the Invention

Group B Streptococcus (GBS), also known as *Streptococcus agalactiae*, is the causative agent of various conditions. In particular, GBS causes:

Early onset neonatal infection.

This infection usually begins *in utero* and causes severe septicaemia and pneumonia in infants, which is lethal if untreated and even with treatment is associated with a 10-20% mortality rate.

Late onset neonatal infection.

This infection occurs in the period shortly after birth until about 3 months of age. It causes a septicaemia, which is complicated by meningitis in 90% of cases. Other focal infections also occur including osteomyelitis, septic arthritis, abscesses and endopthalmitis.

Adult infections.

These appear to be increasingly common and occur most frequently in women who have just delivered a baby, the elderly and the immunocompromised. They are characterised by septicaemia and focal infections including osteomyelitis, septic arthritis, abscesses and endopthalmitis.

Urinary tract infections.

GBS is a cause of urinary tract infections and in pregnancy accounts for about 10% of all infections.

Veterinary infections.

GBS causes chronic mastitis in cows. This, in turn, leads to reduced milk production and is therefore of considerable economic importance.

GBS infections can be treated with antibiotics. However, immunisation is preferable. It is therefore desirable to develop an immunogen that could be used in a therapeutically-effective vaccine.

Summary of the Invention

According to the present invention, a partial GBS gene sequence for the protein Non-phosphorylating, NADP-Dependent Glyceraldehyde-3-Phosphate Dehydrogenase (NPGAP-3-DH) has been found which represents an outer surface protein.

In one aspect of the invention, the use of this protein in a recombinant protein vaccine is described. This vaccine may be administered to females either prior to, or during pregnancy to protect mother and neonate against infection by GBS.

The gene sequence may be first genetically altered to increase the antigenicity of the encoded protein.

Brief Description of the Drawings

The invention will now be described in detail with reference to the accompanying figures, wherein:

Figure 1 shows the partial nucleotide sequence and the deduced amino acid sequence of the GBS NPGAP-3-DH.

Figure 2a shows peptide sequence of the GBS NPGAP-3-DH obtained from MS/MS peptide sequencing

Figure 2b shows the sequence of oligonucleotides derived from the sequences in 2a used for PCR amplification of GBS NPGAP-3-DH.

Description of the Invention

Because of its extracellular or cell surface location, the protein of the present invention may be a suitable candidate for the production of therapeutically-effective vaccines against GBS. The term "therapeutically-effective" is intended to include the prophylactic effect of the vaccines. For example, a recombinant protein may be used, as an antigen for direct administration to an individual. The protein may be isolated directly from GBS or expressed in any suitable expression system, e.g. *Lactococcus lactis*. It is preferably administered with an adjuvant, e.g. alum.

The protein may be a mutant protein in comparison to wild-type protein, a fragment of the protein or a combination of different fragments, provided an effective immune response is generated.

An alternative approach is to use a live attenuated GBS vaccine. This may be produced by deleting the gene that encodes the protein. Preferably, the GBS strain comprises additional virulence gene mutations.

The protein (or fragments thereof) of the present invention may also be used to produce monoclonal and polyclonal antibodies for use in passive immunisation.

In a further embodiment of the invention, the protein or corresponding polynucleotide may be used as a target for screening potentially useful drugs, especially antimicrobials. Suitable drugs may be selected for their ability to bind to the protein to exert their effects. Assays for screening for suitable drugs and which make use of the protein of the invention will be apparent to those skilled in the art.

Although the protein has been described for use in the treatment of individuals, veterinary uses of the protein are also considered to be within the scope of the

present invention. In particular, the protein or the vaccines may be used in the treatment of chronic mastitis, especially in cows.

The present invention is described with reference to Group B Streptococcal strain M732. However, all the GBS strains and many other bacterial strains are likely to include related proteins having amino acid sequence homology with the protein of M732. Organisms likely to contain the proteins include, but are not limited to, *S. pneumoniae*, *S. pyogenes*, *S. suis*, *S. milleri*, Group C and Group G *Streptococci* and *Enterococci*. Vaccines to each of these may be developed in the same way as described for GBS.

Preferably, the proteins that may be useful for the production of vaccines have greater than 40% sequence similarity with the protein of M732. More preferably, the proteins have greater than 60% sequence similarity. Most preferably, the proteins have greater than 80% sequence similarity.

The protein of the present invention was identified as follows:

Todd-Hewitt Broth was inoculated with GBS and allowed to grow overnight at 37°C. The cells were harvested by centrifugation and washed with Phosphate Buffered Saline (PBS). The cells were resuspended in an osmotic buffer (20%(w/v) Sucrose, 20mM Tris-HCl pH 7.0, 10mM MgCl2) containing protease inhibitors (1 mM PMSF, 10 µM Iodoeacetic Acid, 10 mM 1,10-Phenanthroline, 1 µM Pepstatin A) and Mutanolysin at a final concentration of 4 Units per microlitre. This was incubated (shaking) at 37°C for 2 hours.

Cells and debris were removed first by high speed centrifugation, then ultra-centrifugation for 1 hour. The resultant supernatant containing cell wall

proteins was concentrated under pressure using an ultrafiltration device (10,000 molecular weight cut-off).

The sample was dialysed against ultra high quality water and lyophilised. After resuspension in loading buffer, the proteins were separated by preparative 2-Dimensional-Gel Electrophoresis. Following Electrophoresis an individual spot was chosen for study. The spot was subjected to in-gel tryptic digestion. The resulting peptides were extracted from the gel and purified using microbore RP-HPLC. Fractions were collected every 45 seconds and a portion of these consistent with the regions of UV absorbance were analysed by Delayed Extraction-Matrix Assisted Laser Desorbtion-Time of Flight Mass Spectrometry (DE-MALDI-TOF-MS). Peptides not observed in a blank preparation were then subjected to sequencing using Nanospray-MS/MS

The Peptide Sequences obtained are shown in Figure 2a.

Using this information, degenerate oligonucleotides were designed to be used in a polymerase chain reaction (PCR) to amplify the DNA segment lying between the peptide sequences identified. The sequences of these oligonucleotides is shown in Figure 2b.

PCR amplification resulted in the production of an (approximately) 400 base pair fragment, which was cloned into the pCR 2.1-TOPO vector (Invitrogen BV, Netherlands) according to manufacturers protocol. This plasmid was termed pMS10. The cloned DNA fragment was sequenced. To obtain a larger amount of sequence this was used to design primers for genomic sequencing of the upstream and downstream region of the original clone. In total approximately 900 nucleotides have now been sequenced, including a defined 3'-termination signal. (Figure 1) The deduced amino acid sequence was used to search

protein databases. Results of this search are shown in Table 1.

As shown in Table 1, homologues to the GBS MS10 gene product can be identified in *Streptococcus mutans*, *Nicotiana plumb*, *Pisum sativum* and *Zea mays*. In all cases the homologues are the genes for the protein Nonphosphorylating, NADP-Dependent Glyceraldehyde-3-Phosphate Dehydrogenase (NPGAP-3-DH). NPGAP-3-DH has been reported as being an important means of generating NADPH for biosynthetic reactions in *S. mutans* (as opposed to NAD-specific GAP-3-DH which satisfies the requirements of the glycolytic pathway) (Boyd, D.A., Cvitkovitch, D. G. and Hamilton, I. R 1995 J. Bacteriol. 177: 2622-2727).

Table 1. Database search results for MS10

Organism	Protein Accession	DNA Accession	Gene Name	% Similarity	% Identity	Alignment Length
Streptococcus mutans	Q59931	L38521	NADP-Dependent Glyceraldehyde-3-Phosphate Dehydrogenase	84	71	289
Pisum sativum	P81406	X75327	NADP-Dependent Glyceraldehyde-3-Phosphate Dehydrogenase	71	55	240
Nicotiana plumbaginifolia	P93338	U87848	NADP-Dependent Glyceraldehyde-3-Phosphate Dehydrogenase	72	55	240
Zea mays	Q43272	X75326	NADP-Dependent Glyceraldehyde-3-Phosphate Dehydrogenase	71	53	240

CLAIMS

1. A protein comprising an amino acid sequence encoded by the polynucleotide defined as MS10 in Figure 1, or a homologue thereof with at least 60% sequence homology.

2. A protein according to claim 1, obtainable from the Group B streptococcal strain M732.

3. A protein according to claim 1 or claim 2, wherein MS10 comprises the nucleotides 1-900.

4. A protein according to any of claims 1 to 3, for use in a method of therapy.

5. A polynucleotide which encodes a protein according to any preceding claim, its complement, or a fragment thereof.

6. The use of a bacterial protein according to any of claims 1 to 4, in the manufacture of a vaccine to treat bacterial infection.

7. The use according to claim 6, wherein the infection is a Group B streptococcal infection.

8. The use according to claim 6 or claim 7, wherein the infection is a focal infection.

9. The use according to claim 6 or claim 7, wherein the infection is a urinary tract infection.

10. Use of a product according to any of claims 1 to 5, for screening potential antimicrobial drugs.

11. An antimicrobial drug selected using the products as defined in claim 10.

12. A vaccine comprising a product according to any of claims 1 to 5.

13. A vaccine comprising a microorganism having a virulence gene deletion, wherein the gene codes for a protein according to any of claims 1 to 4.

14. An antibody raised against a protein according to any of claims 1 to 4.

Figure 1. Nucleotide and deduced amino acid sequence of clone MS10

```
        10                  30                  50
TGTTTAACCCACCAACACAAGGTCAGTCTCAGACTTGTTTTAGCAAAAGC
C  L  T  H  Q  H  K  V  S  L  R  L  V  L  A  K  A

        60                  80                  100
TTTTGCAGAAGCAGGTCTTCCAGCAGGTGTCTTTAATACTATTACAGGAC
 F  A  E  A  G  L  P  A  G  V  F  N  T  I  T  G  R

        110                 130                 150
GCGGTTCTGAGATTGGAGATTACATTGTTGAGCATGAAGAAGTTAATTTT
  G  S  E  I  G  D  Y  I  V  E  H  E  E  V  N  F

        160                 180                 200
ATTAACTTTACAGGATCAACGCCAGTTGGACAACGTATTGGTAAGTTGGC
I  N  F  T  G  S  T  P  V  G  N  R  I  G  K  L  A

        210                 230                 250
AGGAATGCGTCCAATTATGCTTGAGTTGGGCGGTAAGGATGCAGGTATCG
 G  M  R  P  I  M  L  E  L  G  G  K  D  A  G  I  V

        260                 280                 300
TCTTAGCTGATGCTGACCTTGATAACGCTGCTAAACAAATCGTTGCAGGT
  L  A  D  A  D  L  D  N  A  A  K  Q  I  V  A  G

        310                 330                 350
GCTTATGATTACTCTGGACAACGCTGTACGGCAATTAAGCGTGTGCTTGT
A  Y  D  Y  S  G  Q  R  C  T  A  I  K  R  V  L  V

        360                 380                 400
CGTTGAAGAAGTTGCWGATGAATTGGCAGAAAAAATATCTGAAAATGTAG
 V  E  E  V  A  D  E  L  A  E  K  I  S  E  N  V  A

        410                 430                 450
CAAAATTATCAGTAGGTGATCCATTTGATAATGCAACGGTGACACCGGTT
  K  L  S  V  G  D  P  F  D  N  A  T  V  T  P  V

        460                 480                 500
ATTGATGATAATTCAGCTGACTTTATTGAAAGCTTAGTAGTAGATGCACG
I  D  D  N  S  A  D  F  I  E  S  L  V  V  D  A  R

        510                 530                 550
TCAAAAAGGTGCGAAAGAATTGAATGAATTTAAACGTGATGGTCGTCTAT
 Q  K  G  A  K  E  L  N  E  F  K  R  D  G  R  L  L

        560                 580                 600
TAACTCCAGGATTGTTTGATCATGTTACTTTAGATATGAAACTAGCTTGG
  T  P  G  L  F  D  H  V  T  L  D  M  K  L  A  W
```

```
        610                   630                   650
GAAGAGCCTTTTGGACCAATTCTCCCAATTATTCGTGTCAAGGATGCAGA
E  E  P  F  G  P  I  L  P  A  I  R  V  K  D  A  E

        660                   680                   700
AGAAGCTGTTGCTATTGCCAACAAATCTGATTTTGGATTACAATCATCAG
 E  A  V  A  I  A  N  K  S  D  E  G  L  Q  K  S  V

        710                   730                   750
TCTTTACACGTGATTTCCAAAAAGCATTTGATATAGCAAATAAACTTGAA
  F  T  R  D  F  Q  K  A  F  D  I  G  N  K  L  E

        760                   780                   800
GTTGGTACAGTTCACATTAACAATAAGACTGGACGTGGTCCWGATAATTT
V  G  T  V  H  I  N  N  K  T  G  R  G  P  D  N  F

        810                   830                   850
CCCATTCTTAGGACTCAAAGGATCTGGTGCAGGTGTTCAAGGTATCAGAT
 P  F  L  G  L  K  G  S  G  A  G  V  Q  G  I  R  Y

        860                   880                   900
ATTCAATTGAAGCAATGACAAATGTAAAATCGATTGTTCTCGATATGAAA
  S  I  E  A  M  T  N  V  K  S  I  V  L  D  M  K

        910                   930                   950
TAG
*
```

Figure 2a. Generated Peptide Sequences for MS10

VVEEVADE(I/L)AEK

GPDNFPF(I/L)G(I/L)K

Figure 2b. Oligonucleotide sequences designed from Peptide sequences in Figure 2a

GTWGTWGAAGAAGTWGCWGATGA

RAAWGGRAAATTATCWGGWCC

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